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PERIODICAL READING ROOM

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(Continued on Inside Back Cover)

THE JOURNAL OF

EDUCATIONAL PSYCHOLOGY

Volume 46 January, 1955 Number 1

THE USE OF DUAL GROUPING IN STUDENT-CENTERED TEACHING

NORMAN E. GRONLUND

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One of the persistent problems in student-centered teaching is that of shifting the major leadership responsibility from the teacher to the students as rapidly and efficiently as possible. Due to the lack of experience in democratic procedures the typical student is very dependent upon the teacher for detailed instructions concerning what to study, when to study and how to study. Consequently, some systematic procedure is necessary in assisting the student to move from this extreme state of dependency to that of an active group member willing to accept the major responsibility for planning and carrying out his learning experiences. This paper will describe how dual grouping was used in an Educational Psychology class as a method of providing such systematic organization to student-centered teaching.

The class consisted of twenty-seven students in an undergraduate Educational Psychology course. A modified problem[1] approach was used to study the application of psychological principles to teaching-learning situations. In general, the procedure consisted of identifying, selecting, analyzing, and developing possible solutions to teaching-learning problems that the students were most likely to face as professional teachers. The following list of objectives, which was given to each student at the beginning of the semester, will clarify the nature of the course in terms of specific outcomes that were expected.

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[1] For a detailed description concerning the assumptions underlying this course approach as well as the procedures used, consult Ray H. Simpson, *Improving Teaching-Learning Processes*. New York: Longmans, Green & Co., 1953, pp. ix, 487.

COURSE OBJECTIVES

1) The ability to solve professional problems requiring a knowledge of psychological principles.

1.1. Skill in identifying professional problems related to the psychological aspects of teaching-learning situations.
  1.11. Recognizes problems that arise in teaching-learning situations.
  1.12. States problems clearly and objectively.
  1.13. Analyzes problems into workable sub-problems.
1.2. Skill in selecting professional problems upon which it is most desirable to work at a specified time.
  1.21. Constructs criteria for the selection of problems.
  1.22. Selects problems that meet criteria.
1.3. Skill in locating and selecting resources for the solution of professional problems.
  1.31. Locates a variety of resource material through the use of the *Educational Index, Review of Educational Research, Psychological Abstracts*, and other guides.
  1.32. Selects resource material which is pertinent to the problem being studied.
1.4. Skill in purposeful and functional professional reading.
  1.41. Reads selectively in terms of the pertinence of the material to the problem. Ignores unessentials.
  1.42. Interprets tables, charts and graphs that are pertinent to the problem.
  1.43. Evaluates the results of research in terms of the adequacy of the sample, the control of variables, and the validity of the conclusions.
1.5. Skill in maintaining a professional learning record that contributes to the solution of professional problems requiring a knowledge of psychological principles.
  1.51. Records material which is pertinent to the problem.
  1.52. Records material which reflects a variety of opinions and points of view.
  1.53. Gives analytical and critical reading reactions to recorded materials.
  1.54. Records material which is sufficient quantitatively to draw valid conclusions.
  1.55. Analyzes and integrates recorded material in summaries.
  1.56. States conclusions which are valid in terms of recorded material.
1.6. Skill in democratic, interpersonal relationships.
  1.61. Actively participates in group discussions.
  1.62. Makes constructive contributions to group work.
  1.63. Shares ideas and responsibilities with other group members.
1.7. Skill in self-evaluation, including self-diagnosis.
  1.71. Recognizes own strengths and limitations in ability to solve professional problems.

1.72. Recognizes own strengths and limitations in interpersonal relationships.
1.73. Objectively evaluates own performance in group work.

It will be noted that the previously mentioned objectives stress process skills which were common goals of all learners. Content objectives were intentionally omitted, since they were to be developed coöperatively by the learners and the instructor with the needs of each individual learner in mind. As developed later, some of these objectives, and their related activities, were those of individual learners, some of small groups, and some were common to the whole class. To add cohesiveness and unity to such diversified activities, as well as to shift from a teacher-centered class to a student-centered class, it seemed desirable to utilize some systematic grouping procedure. A dual grouping system, consisting of permanent work groups and committees, was finally devised.

FORMING PERMANENT WORK GROUPS AND COMMITTEES

During the first several weeks various types of groups were utilized. General class discussions were used in dealing with problems of common interest. When activities could be most efficiently carried out by small group work the class was divided up into groups ranging from four to six in number. At the beginning of the semester students were arbitrarily assigned to work groups. During the identification and selection of professional problems requiring a knowledge of psychological principles the students first met in groups according to their major teaching fields and later met in groups according to the professional problems they had selected for study. This flexibility in grouping, in addition to meeting the needs of the current activities in class, enabled the students to broaden their acquaintanceships among the class members.

When it was felt that students had had sufficient contact with other members of the class to make valid choices of work companions, permanent work groups and committees were formed. They were formed in the following manner:

1) *Students were asked to write the names of five class members with whom they most preferred to work for the remainder of the semester.*—It was emphasized that it would be impossible to arrange groups so that students would get all of their choices. However, each student was assured that his choices would be given first preference, mutual

choices would be considered next, and finally other students choosing him would be taken into account.

2) *The students' choices of work companions were analyzed by the instructor through the use of a matrix table.*[2] This analysis resulted in six permanent work groups. Four of the groups contained five students, one contained four students and one contained three students. An attempt was made to keep the work groups at five, since there were to be five committees, with each member of the work group serving on a committee. The value of this arrangement will be clarified when the functions of the work groups and the committees are discussed later. Since there were twenty-seven students in class, it appeared best to have two smaller groups of four and three students rather than only one small group of two students.

With the above arrangement of groups, sixty-four of the students' choices of work companions were satisfied. Consequently, the majority of students were placed in groups with two or more of the classmates they had chosen. In four instances it was necessary to place students in groups where they had chosen only one member of the group. However, in all four cases the students had received one or more choices from some member of the group to which they were assigned.

There were forty-eight reciprocated choices among the sixty-four student choices that were satisfied. In other words, the groups were extremely cohesive in social structure with a majority of mutual companions present in each group.

3) *Students met in the six permanent work groups, resulting from the sociometric analysis and appointed each member to one of the following committees: advisory, evaluation, presentation, resource, and visual aids.*—The nature and purpose of the dual grouping system was explained before committee appointments were made. It was pointed out that each member of a permanent work group would serve on a different committee. Consequently, each committee would contain one representative from each work group. This was desirable since the committee work would be concerned mainly with service activities related to the smooth functioning of classroom experiences and total representation was desired. To provide some basis for appointing committee members, the general re-

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[2] Merle M. Chlsen, "Helping teachers interpret sociometric test data," *The Journal of Teacher Education*, 2, June, 1951, pp. 99–104.

sponsibilities of each committee were outlined. It was understood that each committee would receive a tentative list of suggested responsibilities, as illustrated on the following pages, to provide further orientation when committee work began. At this time, the fact was stressed that the member of each work group appointed to the advisory committee would also serve as chairman of his work group. This was emphasized as a key appointment, since these students would be responsible for the leadership of their work groups, as well as representing them in planning future course activities with the instructor.

After the nature and purpose of dual grouping had been clarified the work groups were free to appoint each of their members to one of the committees. Some groups did this by voting, others through discussion and mutual agreement.

4) *Students met in committees and elected a chairman of each committee.*—As soon as the committees were appointed a meeting of each committee was held. During this first meeting the chairmen were elected and each committee began work on an assigned task. The instructor moved from committee to committee clarifying the nature of their first responsibility and helping them get started with it. The advisory committee assisted the instructor in planning the next class meeting. The evaluation committee began to set up criteria for evaluating student performance in permanent work groups. The presentation committee began to set up criteria for evaluating students' presentations in class. The resource committee began to compile a list of reviewing, abstracting and index services available in the library. The visual aids committee began reviewing the films that might be suitable for use in class. Committee work went ahead rapidly during this first meeting.

When permanent work groups and committees were formed, as described above, each member in class received a list of suggested responsibilities for these various groups, as well as a two-fold chart indicating the permanent work group and committee to which each student belonged. It was agreed that this tentative list of responsibilities would be reviewed and additions or modifications would be considered at future meetings.

SUGGESTED RESPONSIBILITIES OF PERMANENT WORK GROUPS AND COMMITTEES

The suggested responsibilities of the permanent work groups and the committees are listed below. Although they are stated in terms

of specific group responsibilities, it is, of course, understood that these responsibilities are shared by the instructor through individual and group contact. In addition, many of these activities will be participated in by the entire class where such participation appears warranted. Work groups and committees should review their suggested responsibilities to determine what additions or modifications appear desirable.

Suggested responsibilities of permanent work groups.—The permanent work groups will continue with the functions previously handled by the informal classroom groups. These include the following responsibilities related to the identification, selection and solution of professional problems requiring a knowledge of psychological principles.

1) Mutual assistance in the further identification of professional problems requiring a knowledge of psychological principles.

2) Mutual assistance in the selection of professional problems upon which it is most desirable to work at a specified time.

3) Mutual assistance in breaking down professional problems selected into workable sub-problems.

4) Review criteria set up for the evaluation of professional problems and sub-problems.

5) Mutual assistance in the evaluation of each other's professional problems and sub-problems in terms of the above criteria.

6) Exchange of information concerning appropriate resources available for the development of solutions to professional problems.

7) Exchange of information on the development and maintenance of the professional learning record.

8) Set up cirteria for evaluation of the professional learning record.

9) Mutual assistance with a periodic evaluation of each other's professional learning record in terms of the above criteria.

10) Mutual assistance in the improvement of interpersonal relationships.

11) Mutual evaluation of the nature and extent of each member's contributions and the effectiveness of their interpersonal relationships in small group work.

12) Other responsibilities. (To be added by students.)

Suggested responsibilities of advisory committee.—The advisory committee is to assist the instructor in planning in-class and out-

of-class activities. The following activities are suggestive of specific responsibilities in this regard:

1) Determine the specific purposes of each class meeting.

2) Decide on the type of assignment necessary to make each class meeting most meaningful.

3) Determine the type of class activities for each class meeting and the amount of time to be devoted to each activity. Suggestive class activities are class discussions, student presentations, small group work, individual work, and committee meetings.

4) Devise methods for evaluating the success of each class meeting. (This responsibility may be referred to the evaluation committee for suggestions and assistance.)

5) Set up a tentative schedule of class meetings for several weeks in advance.

6) Revise tentative class schedule in accordance with class members suggestions for the improvement of class meetings, and in accordance with the needs of students arising from the on-going teaching-learning process.

7) Other responsibilities. (To be added by students.)

Suggested responsibilities of evaluation committee.—The evaluation committee is responsible for setting-up criteria and devising instruments for the evaluation of student and instructor performance. The following activities are suggestive of specific responsibilities in this area:

1) Set up criteria for evaluating the performance of students in small group work (permanent work groups and committees).

2) Devise student rating scale in harmony with the above criteria.

3) Set up criteria for evaluating the performance of the instructor in all phases of in-class activity and related out-of-class activities, such as individual conferences, out-of-class group meetings, preparation, etc.

4) Devise teacher rating scale in harmony with the above criteria.

5) Provide other committees with assistance in setting up criteria or devising instruments of evaluation.

6) Administer student and teacher rating scales.

7) Other responsibilities. (To be added by students.)

Suggested responsibilities of presentation committee.—The presen-

tation committee is the clearing house for all student presentations. Each student will have his presentation approved by this committee and then schedule a time for his presentation with the advisory committee. The following activities are suggestive of specific responsibilities of the presentation committee:

1) Set up criteria regarding the nature and content of an acceptable student presentation.

2) Set up an outline which students can use in applying for permission to make a class presentation. This would include such things as purpose of presentation, main points to be covered, method of presentation, etc.

3) Devise rating scale for evaluating the success of students' presentations.

4) Administer rating scale after each student's presentation.

5) Other responsibilities. (To be added by students.)

Suggested responsibilities of resource committee.—The resource committee is responsible for keeping the class members informed concerning the location, selection and utilization of resources related to the solution of professional problems requiring a knowledge of psychological principles. The suggested responsibilities of this committee are indicated below:

1) Survey the reviewing, abstracting, and index services available in the library, noting their location.

2) Compile a list of the above services available indicating the types of material that can be located with each, the frequency with which issues appear, and where they may be found in the library.

3) Prepare a brief list of suggestions for the most efficient use of the library.

4) Prepare a list of resources other than professional books and journals that might be utilized in the solution of professional problems.

5) Other responsibilities. (To be added by students.)

Suggested responsibilities of visual aids committee.—The visual aids committee is responsible for keeping the class members informed concerning the films available in educational psychology, the method of ordering the previewing films, and the principles underlying their effective use in the classroom. All students will clear with this committee if they use visual aids in their presenta-

tions. The suggested responsibilities of this committee are as follows:

1) Compile a list of available films in educational psychology.

2) Prepare a list of purposes for which visual aids might be used.

3) Prepare an outline of the necessary steps in ordering and previewing films from the Visual Aids Service.

4) Prepare a list of suggestions for the most efficient use of visual aids in the classroom.

5) Other responsibilities. (To be added by students.)

All of the above responsibilities are to be carried out under the guidance of the instructor. Criteria and instruments of evaluation constructed by committees are subject to revision and final approval by a majority of the class membership, as well as by the instructor.

This list of responsibilities may indicate too much structure for a student-centered class. However, it was stressed that these were merely suggested responsibilities to give work groups and committees something tangible to work on when first organized. This structuring did seem to remove much of the initial confusion that usually appears when major responsibility for planning and carrying out classroom activities is shifted from teacher to students. As the students became more experienced in group work they did modify some of the suggested responsibilities and added others.

ADVANTAGES OF THE DUAL GROUPING SYSTEM

The forming of permanent work groups and committees, as described above, resulted in a dual grouping system illustrated in the accompanying diagram. The permanent work groups are represented by the six columns and the committees appear in the five rows.

This two-fold chart was used to indicate the permanent work group and the committee to which each student belonged. Since each member of the advisory committee is also chairman of a work group, the names of students on this committee were placed across the top of the chart. The remaining committees were placed down the side of the chart in alphabetical order. The students' names and their major teaching fields were then placed in the squares indicating their respective work group and committee

Permanent Work Groups

Committees	I	II	III	IV	V	VI
Advisory (also chairmen of work groups)	John 1 Smith (Biology)	Don 1 Jackson (History)	Mary 1 Jones (English)	June 1 Hill 2 (Home Ec.)	Bill 1 Brown (Phys. Ed.)	Betty 1 Olson
Evaluation			Martha 2 Black (English)			
Presentation			Jim Johnson (English)		2	
Resource	2		Henry Green (English)			
Visual Aids		2	Ann Morgan (English)			

1—Chairmen of work groups; 2—Chairmen of committees.

appointments, as illustrated on the chart for permanent work group III. The completed chart was duplicated and given to the class members for their orientation.

The advantages of this method of grouping may be obvious from the chart. However, the following unique advantages occurred to the writer during the use of this dual grouping system:

1) *Each student has an opportunity to work with mutual friends as well as to develop new acquaintances.*—Since the permanent work groups are based on sociometric choosing, each student has an opportunity to work with several of his mutual friends during work-group sessions. The committees cut across these sociometric choices, so during committee work the student is provided with an opportunity to develop new acquaintances among other class members.

2) *Every member of the class has an active rôle in assisting with the on-going teaching-learning process.*—This has several advantages. First, no student feels left out in the planning and carrying out of classroom activities since everyone serves on a committee. Second, the committees are able to meet during class time with each class member having a definite responsibility. Third, and probably most important, all students obtain experience in apply-

ing the psychological facts and principles that are learned through individual study and general class discussions. The classroom becomes a learning laboratory where theories are put into practice. The unique contribution of dual grouping, in this regard, is the fact that these activities are not dominated by a few aggressive individuals. This method of grouping spreads the responsibilities among the class members, giving them all an opportunity to participate. Studies, such as that of Lewin,[3] suggest that this active participation is essential if the teacher's on-the-job behavior is to be improved.

3) *Dual grouping provides an efficient multiple communication system.*—In each work group there is a member of each committee, and in each committee there is a member of each work group. Consequently, during work-group sessions there is a committee member available to answer questions related to the service activities of each committee. Likewise, suggestions for improving any of these service activities can be jotted down by the respective committee member and carried back to the next committee meeting. It can readily be seen that this also works in reverse. For example, when the advisory committee has set up tentative plans for classroom activities, each committee member can carry it back to his respective work group for discussion and modification before presenting it to the entire class for approval. This multiple communication system prevents much confusion in both work groups and committees, since each student has contact with a representative of every work group and every committee. The multiple contacts of each student are illustrated in the two-fold chart described previously. It will be noted that Mary Jones meets with the students listed across the chart in her row during meetings of the advisory committee, and she meets with the students listed down the chart in her column during meetings of permanent work group III.

4) *The opportunities for experience in leadership are expanded.*—Ten chairmen are required, six for the permanent work groups and four additional for the committees. With dual grouping the only possible overlap in leadership responsibility is the chairman

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[3] K. Lewin, *The Relative Effectiveness of a Lecture Method and Method of Group Decision for Changing Food Habits.* Washington, D. C.: Committee on Food Habits, National Research Council, June, 1942. (Mineographed)

of the advisory committee who is already chairman of his work group. The nature of dual grouping forces the remaining chairmenships to be spread among the other class members.

5) *Students have an opportunity to work with class members in their own major teaching fields as well as with class members in other teaching fields.*—The work groups, based on sociometric choosing, are usually fairly homogeneous with respect to the major teaching fields of their members. Thus, in the permanent work groups students benefit from the ideas of classmates with similar interests and similar teaching objectives. Since committees cut across these work groups, students also have an opportunity to share viewpoints and discuss issues with class members in different major teaching fields. This type of small group work is very realistic in terms of the students' future departmental and inter-departmental committee work in the public schools.

6) *Student evaluation of other group members is less biased, since dual grouping makes dual evaluation possible.*—Each student is able to evaluate the performance of other students in both his permanent work group and in his committee. Since the permanent work groups contain a large number of mutual friends, it is expected that the students evaluations will be slightly inflated due to the halo affect. However, the committees cut across sociometric choices and therefore contain relatively few mutual friends. Thus the halo affect is reduced to a minimum, and committee evaluations serve as a check on the evaluations received in permanent work groups.

The above advantages are those which appear unique to the functioning of the dual grouping system. There has been no attempt to include the general advantages of student-centered teaching, except as they relate to this method of grouping. However, it should be apparent that with these, or similar classroom procedures, students are learning more than how to work together in groups and committees; they are learning a realistic approach to the solution of professional problems requiring a knowledge of psychological principles; they are developing skill in planning democratic learning experiences, preparing for them, carrying them out, and evaluating the results; in general, they are obtaining both theory and practice in the application of psychological principles to classroom teaching-learning situations. This not only makes the psychological principles more meaningful to the

students, but it also provides them with experiences which later can be utilized in their own teaching. As our public schools shift from a teacher-dominated classroom to student-centered teaching, it appears essential that teachers-in-training be provided with experiences in student-teacher planning. Dual grouping appears to be a systematic procedure for providing these experiences.

STUDENTS' EVALUATION OF THE COURSE

Although no intensive effort was made to measure the specific benefits derived from the use of dual grouping, the students' anonymous evaluations of the course reflect directly and indirectly upon the values of this method. On a four point rating scale, over two-thirds of the students indicated that the following conditions existed 'almost all of the time'; the majority of the remaining students indicated that they existed 'most of the time'; two students, or less, indicated that they existed only 'some of the time'; and no students indicated that they existed 'none of the time'.

1) The course had definite goals.
2) The goals of the course were attained.
3) The class periods were well organized and well used.
4) The class periods were interesting.
5) Class time was not wasted in consideration of questions which had little or no significance.
6) Questions from class members were encouraged and carefully considered.
7) Assignments were clear and carefully given.
8) The course content was functional and related to teaching situtions.
9) Experience in this course has been helpful in leading to more independent and critical thinking.
10) Evaluation of the students' work was related to course goals and was fair.

The above items are only indirectly related to the method of grouping used. However, they do imply that the course did not disintegrate into aimless discussions of plans and procedures for carrying out the classroom activities. Items 3) and 5) probably have the most direct bearing on this point. It is felt that this system of grouping, with its provision for definite student responsibilities, contributed to the organization of class periods and to the prevention of wasted time.

In addition to rating the course on the above points, the students were requested to add any comments that would be helpful in improving the course. They were almost unanimous in suggesting that the permanent work groups and committees be organized earlier, in order to avoid the initial confusion they had experienced in the course. Although it is felt by the instructor that the dual-grouping system contributed to the reduction of this initial confusion, there is no claim that it can, or should, remove it entirely. When students first take over the major responsibility for planning and carrying out their learning experiences a certain amount of confusion is inevitable.

The following student comment, given anonymously at the end of the course, illustrates the problem of adjusting to student-centered teaching: "Because I have been accustomed to teacher-dominated courses, the first few weeks were highly frustrating. However, once adjusted to it I enjoyed the course immensely and feel that for once a course will be of value in my teaching. I do feel that I may have neglected my other courses and spent too much time on this one."

The last part of this reaction reflects the motivation that may result from student-centered teaching. Although time was alloted for committee meetings in class, most of the committees voluntarily met out of class on frequent occasions. It is entirely possible that without these out-of-class meetings the dual-grouping system would have been less effective, due to the amount of class time which would then have been needed for committee work.

In addition to the relatively large amount of class time required for planning and carrying out group responsibilities, there are two other persistent problems related to the course approach described above. One is concerned with the amount of direction given by the teacher. The other is related to how well the basic principles of educational psychology are covered.

The course evaluations revealed a discrepancy in the students' perceptions of the amount of direction provided by the teacher. Typical reactions concerning the lack of direction are indicated in the following students' comments:

"At times we wasted time by being unable to make up our minds. Couldn't you help avoid this?" "Perhaps a little more guidance on the part of the instructor would be helpful. However, this course is such that probably too much guidance is wrong."

In contrast to the above plea for more direction and guidance, one student commented: "This course is operated on a democratic principle but everyone feels that they still have to do what the instructor would like them to do. Perhaps most of us are so steeped in traditional procedures that we cannot appreciate democratic procedures."

This conflict in students' perceptions of the extent to which the teacher dominated the class may be partly due to the varying states of dependency among the students. Some would like more direction and others would prefer more freedom in planning their learning experiences. These contrasting feelings were evident when the permanent work groups and committees were presented with the list of suggested responsibilities. Although it was stressed that these were merely suggestive, some class members wanted more details concerning these responsibilities and how they should be carried out, while others felt the duties were too highly structured and didn't permit enough student initiative. Thus, knowing how much direction to give students and when to introduce that direction is one of the persistent problems of this course approach.

The problem of getting a comprehensive coverage of the basic psychological principles related to teaching-learning situations is closely related to the problem of how much teacher direction should be given. Although one does not get a coverage of all conventional material with a problem approach, one expects to bring out the main psychological principles that underlie effective teaching. Several students raised questions concerning the lack of a comprehensive coverage in this course. The following is a typical comment in this regard: "The problem approach to studying has its advantages, but I have worked on only three specific problems. I wonder if I got a complete picture of the field. That is—there may be many principles, ideas, generalizations, and applications that I did not encounter."

This is a valid criticism since the range of material was not as extensive as that covered in a teacher-dominated course. However, with this type of approach, one attempts to train the student so he will continue independent study on the job. Extensiveness of coverage may be partially sacrificed to attain this goal. In addition, it should be pointed out that there is a tendency on the part of the students to overlook the general significance of their classroom activities unless the application of these experiences is

pointed out to them. For example, the general applicability of the principles and procedures of evaluating this course was not recognized until the class members had general class discussions concerning the utilization of these same principles in their own teaching. Getting the students to generalize from their experiences in work groups, committees and class discussions requires the constant attention of the instructor. Without this generalization, the students are unable to recognize that most of the material in a beginning educational psychology course is being covered, but in a different way. The following student comment reflects a sudden realization that content was fairly well covered in the course: (The test referred to is a comprehensive multiple-choice test that was responded to out of class, at the end of the course.) "I didn't realize how much I had gained from the professional records, panel discussions, group work, and class discussions until I was looking over the take-home test. I then realized we had discussed many of the concepts in the test."

The student evaluation material presented above is not offered as proof that this is the best approach to student-centered teaching. It is merely descriptive of the various student reactions to one instructor's attempt to use a systematic grouping method to facilitate student-teacher planning. It is hoped that these student reactions will provide additional insights for any instructor who might experiment with dual grouping in his own teaching.

SOLUTIONS BY TEAMS AND BY INDIVIDUALS TO A FIELD PROBLEM AT DIFFERENT LEVELS OF REALITY[1]

IRVING LORGE, JACOB TUCKMAN, LOUIS AIKMAN, JOSEPH SPIEGEL and GILDA MOSS

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In teaching and in training, problems are presented most often verbally, usually as a printed text. Despite the preponderance of practice employing verbal presentation, advanced instructional thinking seems to favor teaching, and hence, learning by realistic modes of presentation. By implication, the order of preference in teaching modes would range, let us say, from the most frequently advocated 'actual real' through the three-dimensional scale model, the two-dimensional photographic representation, to the least recommended 'verbal abstraction'. Such modes of presentation are assumed to be a range of steps or levels differing in remoteness from reality. Of course, additional levels of remoteness may be specified. For instance, in learning to pilot an airplane, other methods of presentation may be employed such as: textbook exposition, diagrammatic representation, exploded assembly diagrams, simulated trainers and actual aircraft.

The purpose of this study is to estimate the difference in the quality of the solution to a practical field problem presented in four settings differing in their degree of remoteness from reality: a) the verbal description, b) the photographic representation, c) the miniature scale model, but not allowing manipulation of parts and materials, d) the miniature scale model allowing manipulation of parts and materials.

In order to estimate the relative effectiveness of different levels of presentation for problem solving, it was considered desirable to find or to devise a problem which (1) could be adapted for presentation at different levels of remoteness from reality, (2) would permit many different solutions of varying quality not only of

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[1] *Studies in Reality*. No. 1. Conducted under AF 18 (600) 341 of the Human Resources Research Institute, Maxwell Air Force Base, by the Institute of Psychological Research, Teachers College, Columbia University, Principal Investigator: Irving Lorge.

thought, but of accomplishment, (3) would have the characteristics of a genuine field situation, usually lacking in most psychological laboratory problems and (4) could be used with groups as well as individuals.

The field problems developed by the Office of Strategic Services during World War II to assess leadership and personal qualities of men appeared to satisfy these criteria. 'The Mined Road Problem'[2] which requires the formulation of a plan for getting a group of five men across a road mined with supersensitive mines which cannot be neutralized or dug up was selected and adapted.

The Mined Road Problem was constructed in reality in wooded terrain. The section of the road which was to be crossed was twelve feet wide and approximately fifty feet long. The limits within which the subjects were permitted to work extended about fifteen feet away from the road on either side. Two-inch tape marked off the road as well as the working limits. On each side of the road were two trees about forty feet high: two were directly opposite one another and just at the edge of the road. Scattered about the work area on the starting side were the following materials which could be utilized in crossing:

2 4″ x 6″ wooden beams, one twelve feet long, the other fourteen feet long
1 8″ x 8″ wooden block, thirty inches long
3 2″ x 4″ boards, four feet long
2 1″ x 4″ boards, eighteen inches long
1 automobile tire
2 ½″ Manila ropes, one twenty-five feet long, the other fifty feet long
1 pulley
1 hammer

After the Mined Road Problem had been constructed in the actual field setting, four methods of presentation were developed:

(1) *The Verbal Description.*—The problem was presented in typed form to the men[3] as follows:

You men are on your way back from a sabotaging mission in enemy-occupied territory. You have just blown up a bridge about a mile from here. According to a prearranged plan, you will meet a guerrilla truck about a mile away from here which leaves you only a very short time to get across this road. You have discovered that this road has been mined with a new

[2] The OSS Assessment Staff. *Assessment of Men.* New York: Rinehart & Co., Inc., 1948.

[3] The OSS Assessment Staff. op. cit., p. 148.

type of enemy mine which is supersensitive and will blow up if anything touches it. The explosion at the bridge has aroused the enemy but as yet they do not know in what direction you are going. Your problem is to get the entire group of five men across the road and leave as little trace as possible of your escape route.

V Bordering the road are trees and scattered around are some wooden beams, some pieces of lumber, some lengths of rope, a few sticks, an old tire, a pulley, a hammer, and some other debris.

After you have decided how you are going to cross the road, one man is to write your plan of action on the paper provided.

You may ask any questions you wish and we will try to answer them as best we can. Remember it is important that you complete this mission as quickly and with as little loss of men and materials as possible. According to your schedule you must meet the guerrilla truck in one hour. Remember also that your performance on this mission will be compared with other members of Air Force Reserve Officers Training Corps personnel.

(2) *The Photographic Representation.*—This presentation consisted of five photographs of the Mined Road Problem taken from five different positions on the original starting side. Each photograph enlarged to 8″ x 10″ was numbered to correspond to the angle from which it was taken. The photographs were bound in a booklet together with a schematic diagram, indicating the positions relative to the terrain from which each photograph was taken. The typed description of the problem presented to the men was identical with that of the Verbal Description except that the following paragraph was substituted for paragraph *V*:

You must cross the road at the spot on the sketch labeled 'mission's present position'. You have five photographs of this mined road taken from five different angles. Photograph no. 1 shows the road from position no. 1 on the sketch. Photographs nos. 2, 3, 4, and 5 show the road from positions 2, 3, 4, and 5 respectively, on the sketch. The white tape in the photographs corresponds to the lines in the sketch indicating the road and working limits.

(3) *The Miniature Scale Model Without Manipulation.*—A miniature scale model of the Mined Road Problem, built to the scale of one inch equals one foot with over-all dimensions about three feet by three feet and with the trees approximately three feet in height, duplicated the actual field situation, i.e., scale representations of beams, crosspieces, tire, ropes, etc. were distributed about the model as in the field.

The typed description of the problem given to the men was identical with that of the Verbal Description except that the

following paragraph was substituted for *V*:

> You must cross the road at this spot which is marked off by the white tape. In determining your plan of action, you may observe but not manipulate any parts of the model or equipment.

(4) *The Miniature Scale Model With Manipulation.*—The same model was used. The essential difference between No. 3 and No. 4 is that the men could manipulate the beams, tire, ropes, etc. The typed description of the problem given to the men was identical with that of the Verbal Description except that the following paragraph was substituted for *V*:

> You must cross the road at this spot—which is marked off by the white tape. In determining your plan of action you may manipulate any parts of the model or equipment.

The subjects were cadets of the Air Force Reserve Officers Training Corps at Columbia College, Columbia University, in Air Science I and Air Science II. These men were fairly homogeneous in background and intelligence, were highly motivated to work with tactical problems, and would maintain the required security about the problem.

Ten teams of five men and ten men as individuals were set the task of solving the problem at each of the four levels of presentation. If the problem was to be presented for team solution, the five team members were brought as a group to the laboratory and given one of the typed descriptions of the problem to read to themselves while the examiner read it aloud. If the problem was to be presented for individual solution, only that person was brought to the laboratory, given the typed description of the problem to read himself while the examiner read it aloud.

Since the information available about specifications of the road, the terrain, and the materials varied from level to level, i.e., according to the form of presentation by the very nature of the presentation method, teams and individuals were permitted and encouraged to ask questions in an attempt to equalize the amounts of information from team to team, from individual to individual, and, more important, among presentations. When an individual or a team asked a question about information that could have been obtained by observation in the actual field setting, e.g., the width of the road, length of the beams, height of the trees, thickness of the rope, such question was answered in required detail.

When the question was not answerable by observation in the actual field setting, e.g., location of the mines, types of mines, ability of men to swing across the road or to broadjump across the road, the examiner stated that he did not have the information. The teams and individuals proceeded with their interrogations and deliberations until the solution was ready to be written. Then either the individual or a member of the team wrote the solution. Thus, eighty written solutions were obtained: ten by teams and ten by individuals for each of the four methods of presentation.

The written solutions of the Mined Road Problem do not represent just one correct solution, but rather they illustrate a rich variety differing not only in the degree of workability or accomplishment, but also varying in the quality of thinking as well. Obviously, a 'go-no go' scoring would be inadequate. To develop a scoring procedure that would credit the quality of solutions, a content analysis of the solutions was made. All solutions were oriented around four major elements: (1) Bridging the road, i.e., the use of beams, a combination of beams, the swinging, broadjumping, throwing men or materials across, making an overhead bridge, etc. (2) Removing the bridging from the road, i.e., any procedure for removing the basic bridging or any secondary bridging. (3) Removing clues indicative of escape or escape route, i.e., materials hidden or carried away. (4) Time, i.e., elapsed time from presentation of problem to the formal written solution. Each point and subpoint in all written solutions was classified by a detailed content analysis. To give a score, each item in the content analysis was assigned a weight or value by giving consideration to the aggregate of factors such as safety, efficiency and quality of thinking. In assigning weights, three members of the research team tested the workability of various solutions in the actual real setting. For instance, it was found by tryout that solutions involving a man swinging by rope from a tree on the starting side would not work except under the joint specific conditions that the rope had to be suspended from a branch at least twenty feet high, and at the same time the man must begin the swing from an elevation of about six feet from someone else's shoulder or from a piece of lumber to get the necessary momentum. Or, it was found that a solution involving a man broadjumping across the road would not work at all since the run space was only fifteen feet long and on an upgrade. The Physical Education

Department of Columbia College stated that it was highly improbable that anyone could broadjump the road under the actual conditions especially if the groups were out of condition or if the broadjumper lacked necessary track equipment. On the other hand, solutions involving throwing a tire with attached rope across to the other side of the road would work even though there was some danger that the rope or tire might hit the road.

After the workability of the solutions had been field-tested, values were assigned to various aspects of the written solutions. For example, in bridging the road with a beam or combination of beams, the fourteen-foot beam was given a weight of 25, whereas the fourteen-foot beam tied to the twelve-foot beam was given a weight of 20; or, to give another instance, the twelve-foot beam tied to the fourteen-foot beam about one foot from its end, spread into an X, was given a weight of 15. The suggested use of a beam without specifying its length was given a weight of 8; whereas the use of the twelve-foot beam (which could not bridge the road) was given a weight of 0. Similarly, removing or leaving clues indicative of the escape route were given differential credits: for example, leaving all materials on the original starting side and removing footprints was given a weight of 25; leaving some materials on the starting side and hiding some materials on the other side and removing footprints from both sides of the road was given a weight of 20; leaving some materials on the starting side of the road and some on the other side and removing footprints was given a weight of 15; no reference to removal of materials on either side of the road, yet implying removal, was given a weight of 7; leaving a rope suspended across the road between two trees was given a negative weight of -8; leaving a beam bridging the road as well as leaving a rope suspended across the road between two trees was given a negative weight of -15.

After the Quality Point Scoring system had been developed, fifteen written solutions selected at random were ranked for over-all workability and goodness of solution by three members of the research team. Independently, the Quality Point Score for each of the fifteen solutions was obtained by summing the separate element weights. The correlation between Quality Point Score and rank for workability approximated unity. The Quality Point Score seems an objective way of appraising goodness of solution.

TABLE 1.—QUALITY POINT SCORE FOR MINED ROAD SOLUTIONS: MEANS AND STANDARD DEVIATIONS, BY TEAMS AND BY INDIVIDUALS AT EACH OF THE FOUR LEVELS OF REMOTENESS FROM REALITY: TEN TEAMS AND TEN INDIVIDUALS AT EACH LEVEL

Level of Remoteness from Reality	Teams		Individuals	
	Mean	SD	Mean	SD
Verbal description	68.9	28.2	25.2	16.8
Photographic representation	54.8	18.3	11.7	9.2
Miniature scale model without manipulation	50.1	24.6	34.0	27.4
Miniature scale model with manipulation	59.0	19.7	36.7	26.3

TABLE 2.—QUALITY POINT SCORE FOR MINED ROAD SOLUTION: ANALYSIS OF VARIANCE BETWEEN TEAMS AND INDIVIDUALS AND AMONG FOUR LEVELS OF REMOTENESS FROM REALITY

Source	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Class (teams and individuals)	19593.8	1	19593.8	35.7*
Treatment (level of reality)	2701.6	3	900.5	1.6
Class X treatment	3025.2	3	1008.4	1.8
Error	39367.2	72	546.8	
Total	64687.8	79	818.8	

* Significant at .01 level.

For teams, and for individuals, at each of the four levels of remoteness from reality, the means and standard deviations of the Quality Point Scores are given in Table 1. The analysis of variance among levels of remoteness from reality and between teams and individuals is presented in Table 2.

The evidence indicates that there are no significant differences among the solutions at the four levels of remoteness from reality. When teams solved the Mined Road Problem, the goodness of the written solutions was approximately equivalent for the Verbal Description, Photographic Representation, Miniature Scale Model Without Manipulation, and Miniature Scale Model With Manipulation. When individuals solved the problem, their written solutions were approximately equivalent at every level of remoteness

from reality. Apparently the written solutions for the four levels cannot be distinguished in terms of quality. But the evidence does show that at every level of remoteness from reality, the written solutions by teams is markedly superior to those by individuals.

The absence of differences in goodness of solution to the Mined Road Problem among levels of presentation may be attributed, at least in part, to the fact that teams and individuals at each level were given the opportunity to obtain equal amounts of information about the problem and its materials either by perception directly, or indirectly by asking questions. This suggests that many of the so-called differences among presentation modes may really represent differences in the amount and kind of information the mode allows. Adjustment for presentation mode does lead to the formulation of equally good hypotheses and, hence, equally good solutions for the problem. The superiority of team solutions over individual solutions in part may be due to the fact that teams of five members ask more questions than do single individuals. Teams, thus, not only get more information, but also seem to evolve many more fruitful hypotheses regarding a solution. The team thus summates information and hypotheses leading to better solutions. This experiment corroborates the effectiveness of groups in the so-called 'Eureka' problems—problems with workable and testable solutions.

A FACTOR ANALYSIS OF THE SRA YOUTH INVENTORY

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The *SRA Youth Inventory* (*1*, *2*) is a needs and problems inventory that has been specifically developed to help teachers, counselors, and school administrators quickly identify the problems of their high-school youth. The items of the Inventory were developed primarily from a content analysis of hundreds of anonymous essays written by a national sample of teen-agers. The items finally selected were divided *a priori* into eight areas called (1) My School, (2) Looking Ahead, (3) About Myself, (4) Getting Along with Others, (5) My Home and Family, (6) Boy Meets Girl, (7) Health, and (8) Things in General. The preliminary form of the Inventory was administered to approximately fifteen thousand students from high schools participating in the Purdue Opinion Panel.

Using a sample of one thousand students drawn from the national sample, the homogeneity of each problem category was established by means of an item analysis. A biserial coefficient of correlation was computed between each item and the total score in each problem area. The item analysis data were used to reassign items from one category to another in order to increase the homogeneity and, hence, the psychological meaning of each area.

Intercorrelations of the total scores for the eight 'purified' problem categories were computed for the sample of one thousand used in the item analysis. Reliabilities for each of the problem areas were also computed, using the Kuder-Richardson Formula, Case II. These intercorrelations and reliabilities are presented in Table 1.

PURPOSE

Although the eight test areas, by virtue of the item analysis, are relatively independent and possess unique variance, they do have variance in common. The entire matrix is a positive manifold. Seven of the twenty-eight intercorrelations are .50 and larger. Any two of these highly intercorrelated tests have a common variance of at least twenty-five per cent. Accordingly, it was the purpose of this study to analyze statistically the overlap of vari-

TABLE 1.—RELIABILITIES AND INTERCORRELATIONS OF TOTAL SCORES FOR THE EIGHT PROBLEM AREAS

(N = 1000)

Area	1	2	3	4	5	6	7	8
1. My School	(.84)	.40	.55	.45	.42	.35	.34	.20
2. Looking Ahead		(.90)	.46	.58	.33	.46	.36	.39
3. About Myself			(.88)	.67	.50	.45	.47	.35
4. Getting Along with Others				(.88)	.46	.59	.51	.48
5. My Home and Family					(.94)	.46	.47	.32
6. Boy Meets Girl						(.87)	.50	.48
7. Health							(.75)	.46
8. Things in General								(.89)

ance in an attempt to identify psychologically meaningful problem factors operating in the eight areas of the Inventory.

PROCEDURE

The matrix of intercorrelations was factor analyzed using Thurstone's centroid method (*3*). Since the reliabilities of the subtests were known, it was possible, once the communalities were determined, to account for the total variance of each subtest (*3*). That part of the variance which is unique was factorially determined and the unique variance was separated into its two parts, the specificity and the error variance.

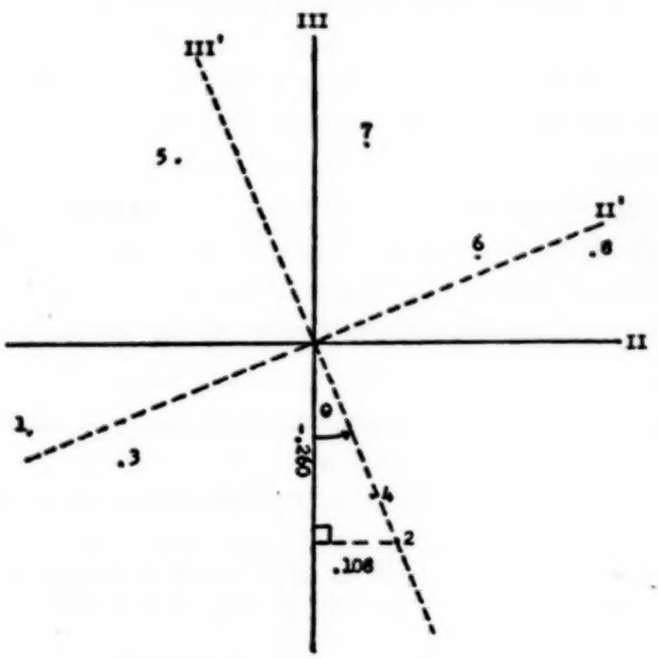
RESULTS

Three factors were extracted from the intercorrelation matrix. The original and rotated factor loadings appear in Table 2. The rotation scheme adopted was a simple counterclockwise rotation in the plane II–III such that θ = arc sin .3837. The projection of the eight test vectors upon the plane II–III before and after rotation appears in Figure 1. It will be noted from Figure 1 and Table 2 that seven of the new loadings in Factors II and III are zero or nearly so. Every subtest has one zero loading in either Factor II or III except Health, which is positively loaded in both. It will also be noted that the rotation has established two bipolar factors (II and III) and a principal factor (I). This rotation system produced the most meaningful structure. Rotation systems were attempted which resulted in a positive manifold of factor loadings but these structures proved to be relatively meaningless.

TABLE 2.—ORIGINAL AND ROTATED FACTOR LOADINGS, WITH THE COMMUNALITIES, UNIQUENESS, SPECIFICITY, AND ERROR FOR THE EIGHT PROBLEM AREAS

Area	Original Factor Loadings			Rotated Factor Loadings			Proportions of Variance			
	k_I	k_{II}	k_{III}	k_I	k_{II}	k_{III}	h_j^2	u_j^2	b_j^2	e_j^2
1. My School	+.601	−.370	−.113	+.601	−.385	+.038	.511	.489	.329	.160
2. Looking Ahead	+.656	+.108	−.260	+.656	.000	−.282	.510	.490	.390	.100
3. About Myself	+.759	−.251	−.155	+.759	−.291	−.047	.663	.337	.217	.120
4. Getting Along with Others	+.812	+.079	−.199	+.812	−.003	−.214	.705	.295	.175	.120
5. My Home and Family	+.637	−.176	+.240	+.637	−.070	+.289	.494	.506	.446	.060
6. Boy Meets Girl	+.715	+.213	+.110	+.715	+.239	+.020	.569	.431	.301	.130
7. Health	+.667	+.070	+.259	+.667	+.164	+.212	.517	.483	.233	.250
8. Things in General	+.582	+.364	+.112	+.582	+.379	−.036	.484	.516	.406	.110

Projection of the Eight Test Vectors[1] upon the Plane II-III, with a Rotation through θ = arc sin .3837 Indicated



[1]Vector Code

	Area
1	My School
2	Looking Ahead
3	About Myself
4	Getting Along with Others
5	My Home and Family
6	Boy Meets Girl
7	Health
8	Things in General

FIG. 1

Table 2 also presents an account of the total variance of each subtest. The total variance has been fractionated into that which is common (h_j^2) and unique (u_j^2) and the unique variance has been broken down into those parts due to specific elements (b_j^2) and to errors of measurement (e_j^2).

DISCUSSION

Interpretation of the Factors.—The naming of Factor I is seemingly obvious since it makes up most of the variance in every problem area. Because of its high loadings in every subtest, this factor is interpretated as a 'General Problems' factor.

Factors II and III proved to be more difficult for extracting a general naming principle. The rotation solution has resulted in two high positive and two high negative loadings in Factor II (see Figure 1 and Table 2). We have a continuum, with Things in General and Boy Meets Girl opposed to My School and About Myself. At first glance, these area titles do not seem to lend themselves to a higher order abstraction. Examination of the problem items per se, however, suggests a scope continuum; that is, the problems expressed seem to progress from those of an internalized, personal nature (My School, About Myself) to those of an externalized, social nature (Boy Meets Girl, Things in General). A few items from each area are reproduced below to illustrate the nature of the continuum. The problems are arranged to progress from the internal to the external pole of the continuum.

Area	*Item*
1) My School	I have difficulty keeping my mind on my studies. I am too restless to stay in school.
2) About Myself	I prefer to be alone, I wonder if I am normal in the way my mind works.
3) Boy Meets Girl	What are good manners on a date? I need more information about sex.
4) Things in General	How can we get honest government? How can I help get rid of intolerance?

Factor II, therefore, in view of the above axis, can be given the

hyphenated title of 'Internal-External' or perhaps 'Egoistic-Social' factor.

Loadings in Factor III set up My Home and Family at one end of a continuum and Looking Ahead and Getting Along with Others at the opposite end. The problems in the above areas suggest a time continuum; that is, problems included in My Home and Family seem to have historical and present-time stress, whereas problems included in Getting Along with Others and Looking Ahead generally place emphasis on the future. Accordingly, Factor III can be looked upon as a 'Historical-Future' factor. Selected problems from the areas under discussion are presented below. The problems range from the historical to the future axis.

Area	*Item*
1) My Home and Family	My parents neglect me. My family tries to hold me down.
2) Getting Along with Others	I want people to like me better. I want to make new friends.
3) Looking Ahead	What career shall I pursue? What are some ways of financing a college education?

The Specific Variance.—The contribution to the total variance of each subtest by the three common factors has now been extracted and identified. Examination of Table 2, however, reveals that considerable specific variance remains to each area. The eight problem areas retain their psychological meaning because of their possession of specific elements above and beyond errors of measurement. The identification of three underlying factors has not destroyed the original problem areas of the Inventory, but has, however, provided more information about the problems confronting teen-agers.

SUMMARY AND CONCLUSIONS

The *SRA Youth Inventory*, its definition, purpose, and construction, was briefly discussed. Special emphasis was placed on the intercorrelation of the eight problem areas and the desirability of a factor analysis was pointed out. The matrix was factor analyzed using Thurstone's centroid method. With the communalities de-

termined, and with the reliabilities known, the total variance for each problem area was accounted for.

The following conclusions are supported:

1) Three underlying factors are operative in the problem areas of the *SRA Youth Inventory*.

2) The factor which contributes most to the variance is identified as a 'General Problems' factor because of its high loadings in every subtest.

3) A second factor is identified as an 'Egoistic-Social' factor.

4) The third factor is called a 'Historical-Future' factor because it suggests a time axis.

5) The eight problem areas contain substantial specific variance after the extraction of the variance due to the common factors and to the errors of measurement.

6) The fractionization of the variance common to all the areas into three meaningful problem factors, coupled with the knowledge of the factors specific to each area, provides more information on the nature of the needs and problems of younger people.

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THE USE OF AN ELECTRONIC COMPUTER IN PRINCIPAL AXES FACTOR ANALYSIS[1]

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Psychology promises to benefit greatly from the development of electronic computers. Most of the day-to-day calculations in psychometrics can be carried out at greater speed and with a higher degree of accuracy on an electronic computer than by more conventional computational techniques. It follows that exact solutions become practicable in situations where psychologists have hitherto been restricted to approximate methods. On the other hand, the transitional period in the changeover to electronic computer procedures is not easy. Programming for an electronic computer is difficult and requires special training, and new skills have to be developed in the recording and handling of tapes.

This report has been prepared to consider the use of the electronic computer for principal axes factor analysis (*9*). The advantages of the principal axes method may be summarized thus:

1) Vectors of factor loadings are orthogonal. In the centroid method, there is a loss of orthogonality, i.e., scalar products of columns of factor loadings are not exactly equal to zero.

2) A maximum of the variance is accounted for by each successive factor; the principal axes solution is thus unique (except where there are multiple latent roots).

3) Because the matrix of latent vectors from which the factor

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[2] We wish to express our deep gratitude to Dr. R. E. Meagher, Director of the Digital Computer Laboratory, and to Dr. J. P. Nash, senior mathematician of the Laboratory, for the way in which they have placed their facilities at our disposal, and for their generous help; and to Mr. R. T. Gregory for preparing the code to give the latent roots and latent vectors of a matrix, from which our program for principal axes factor loadings was derived.

loadings are derived is orthonormal, the inverse of the matrix of factor loadings may be readily computed. This makes it somewhat easier to get the factor measurements.

4) Tests of significance have been developed for the successive latent roots (i.e., the sums of squares of loadings in successive factors) if unities are inserted in the principal diagonal of the correlation matrix (*2*, *3*).

The difficulty hitherto has lain in computing the latent roots and latent vectors from which the principal axes factor loadings are derived. As a result, very few principal axes solutions are available in the psychological literature. The largest correlation matrix handled by the method appears to have been one of thirty-one variables. This was calculated by Deemer, and has not been published.* Davis (*6*, *7*) has worked with matrices of order 14 and order 9, and Kelley (*12*) has handled one of order 10 and another of order 9. We understand that sixty hours' computing was required for a matrix of order 7 when results were needed with four-place accuracy (*5*), and Holzinger and Harman (*8*, p. 175) report that one hundred ten hours were needed to extract the first two factors for a matrix of order 24.

The centroid method of factor analysis has generally been used by psychologists in preference to the principal axes method. The advantage of the centroid method has been that it has given a reasonably good approximation to a principal axes factor analysis in only a small part of the time otherwise required. The mathematically superior principal axes method has demanded too much arithmetic. With an electronic computer, however, it is quite simple to get the principal axes factor loadings once the code has been written. The factor loadings for a correlation matrix of order 7 are computed and punched on tape in about a minute, with results to about ten decimal places; a matrix of order 20 is analyzed in about ten minutes, giving the entire set of twenty factors.[3] Even allowing ten or even twenty times as long as this for preparation of tapes and checking of results, this is much

* F. B. Davis. Personal communication March, 1954.

[3] Two further examples may be given of the shortened times for computation using the Illiac. The full set of product-moment correlations between forty tests can be calculated and results punched on tape in about fifteen minutes. Again, a set of equations involving about forty unknowns can be solved in about five minutes.

quicker than current methods of computation. Hence the principal axes method is to be preferred to the centroid as the standard starting point in factor analysis whenever an electronic computer is available. When rotation of axes is decided upon, it will be the principal axes solution which is transformed.

THE ELECTRONIC COMPUTER

Several years ago the University of Illinois established a research unit for work in high-speed computing. The Ordvac, built on contract for Aberdeen Proving Ground, Maryland, was completed towards the end of 1951. A rather similar machine, the Illiac, was completed in the latter part of 1952, and is available for the University's own use.

The principal features of the two machines are:

1) *The high speed of operation.*—The Illiac receives its orders and problem data from teletype tapes run through a high-speed photo-electric reader at the rate of about one thousand eleven-place decimal numbers per minute. Once the input of orders and data is complete, the calculations begin. The Illiac averages about one thousand arithmetical operations per second, where by arithmetical operation is meant a completed addition, subtraction, multiplication or division. As soon as the calculations are completed, the results are punched out as decimal numbers on a tape at the rate of about one hundred eleven-place numbers per minute.

2) *The high degree of accuracy.*—The Illiac gives results to as many as eleven decimal places if so ordered. When allowance is made for (a) rounding-off errors in the final position and (b) the scaling involving the introduction of a leading zero, results are generally accurate to at least nine decimal places.

3) *The rather limited storage capacity at present.*—In all, there are only 1024 positions in the 'memory', and some two hundred of these must be allocated to the orders for the principal axes factor loadings, so that only about eight hundred numbers may be retained by the 'memory' at any one time. It follows that there is a restriction at present on the size of matrix that may be analyzed. A correlation matrix of order 23 is the largest for which a full set of principal axes factor loadings can be obtained. A somewhat larger matrix can be diagonalized by making two or more analyses in succession, and printing a selection of factor loadings on each occasion; we ourselves have handled a matrix of order 30

in this way.[4] The Digital Computer Laboratory intends to add a magnetic storage drum to the Illiac, and when this is done there will be a great increase in storage space.

4) *The complexity of the coding.*—A scheme of numerical analysis is required in a form that may be handled by the machine, and then orders have to be written in the form of code-numbers for each stage of the arithmetic. The coding is the most difficult operation in the use of the machine. The more skilled the programming, the more succinctly orders may be expressed and, accordingly, the more space is available for the numbers which are being operated upon. There are usually alternative methods for any standard statistical operation. The programmer has to select a method which (a) is easily coded, (b) is economical in its use of storage space, and (c) involves proportionately fewer arithmetical operations. (In the usual type of psychological calculation customarily carried out by more conventional methods, this third proviso is not important, since computing time is generally negligible, but it is important for those types of analysis which require extensive electronic computer time—fifteen minutes or more of electronic computer time for calculating, say—because machine time is valuable.)

On a desk calculator, the principal axes loadings for the first factor are obtained by the multiplications $R^{(0)} \cdot a^{(1)}$, $R^{(0)} \cdot a^{(2)}$, etc., where $R^{(0)}$ = the correlation matrix and $a^{(1)}$, $a^{(2)}$, etc., denote trial vectors, until the values of the successive trial vectors $a^{(i)}$, $a^{(i+1)}$ are stationary or differ by less than any specified amount.

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[4] Factor analyses have been made of as many as two hundred variables on the Illiac, using the square root method of factor analysis, where the computational procedure may be arranged so that only one column of the correlation matrix is operated upon at any one time. (See: C. F. Wrigley and L. L. McQuitty, *The Square Root Method of Factor Analysis: A Re-examination and a Shortened Procedure*. Manuscript on file in the University of Illinois Library, 1953). Let the square root factor loadings be denoted by G. Then, by solving the equation $(G'G - \lambda I)\, v = 0$, where v denotes the latent vectors of G'G, we may find the orthogonal transformation matrix V such that $GV = \overline{F}$, where $\overline{F}$ is orthogonal. The factor loadings $\overline{F}$ are then equal to the principal axes factor loadings of $\overline{R}$, where $\overline{R} = GG'$. By taking sufficiently many factors, $\overline{R}$ may be made to approximate increasingly closely to R, so that it is appropriate to speak of this procedure as giving an indirect principal axes factor analysis of R. By means of this procedure, the Illiac is restricted to approximately thirty factors instead of to approximately thirty variables.

After convergence, the trial vector is proportional to the first latent vector, and the largest element in the trial vector is equal to the first latent root. Then $f_{i1} = u_{i1} \cdot \sqrt{\lambda_1}$. The correlation matrix $R^{(0)}$ is reduced to the first residual matrix $R^{(1)}$, and the operation is repeated. Various modifications have been introduced to systematize computational procedure and accelerate rate of convergence (*1*, *4*, *10*).

This procedure designed for desk calculator would be clumsy on an electronic computer. The present Illiac program provides for the diagonalization of the correlation matrix by sine-cosine transformations to reduce each off-diagonal element to zero. For example, in diagonalizing a correlation matrix of order 3

$$\begin{bmatrix} r_{11} & & \\ r_{21} & r_{22} & \\ r_{31} & r_{32} & r_{33} \end{bmatrix},$$

where the matrix is symmetrical so that we record only the lower left-hand portion, the electronic computer first makes the sine-cosine transformation which reduces r_{21} to zero, by multiplying R by the orthogonal transformation matrix.

$$\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

The appropriate angle θ and its sine and cosine are determined by the machine. The electronic computer then makes a second sine-cosine transformation so that r_{31} becomes zero, and then a third so that r_{32} becomes zero. This represents one complete iteration. By this time, however, r_{21} and r_{31} are no longer zero. Nonetheless, it may be shown that this procedure gives convergence, so that after a number of iterations all non-diagonal elements are zero. In another part of the 'memory', an identity matrix of order 3 is stored which records the net transformation, and the resultant is the matrix of latent vectors, which is then converted by the machine to the matrix of factor loadings. The elements remaining in the principal diagonal of R after its diagonalization are the latent roots.

This sine-cosine procedure for the diagonalization of a matrix was originally developed by Jacobi (*11*). The method was pre-

sented with explicit reference to the calculation of principal axes factor loadings by Kelley (*12*) in 1935.

With the correlation matrices which can be analyzed with the present memory capacity, this method works very satisfactorily, but since the time required for convergence increases approximately according to the cube of the order of the matrix—e.g., an order 30 matrix requires approximately eight times as long to converge as an order 15 matrix—the analyses of large matrices theoretically made possible by the addition of the storage drum would require so much calculational time that they would be impractical. A code is planned using a method devised by Lanczos (*13*) which, while more elaborate, nonetheless requires fewer operations and is expected to cut computational time to about one-fifth that of the sine-cosine method.

The difficulty of coding even the present relatively simple mathematical procedure becomes evident when we consider that an electronic computer can use only a few simple types of arithmetical operations in carrying out its computations. During the course of the solution of a principal axes problem, the machine selects elements from a matrix, generates sine-cosine matrices and square roots, makes linear transformations, converts the latent vector elements to factor loadings, and punches results on teletype tape. Orders have to be written to carry out all these operations in the appropriate sequence.

Further, each relay in the machine has only two positions—a unit position and a zero position. Since this feature makes use of the decimal system impossible, the machine uses binary numbers which, for coding convenience, are themselves grouped into sexadecimals. The first portion of the order code provides for transformation of decimal numbers to binary numbers during the input, and there is provision at the end of the order code for the converse transformation at the time of output of the results.

Some months' work was needed for preparing the code.[5] However, this one set of orders may be used for all principal axes factor analyses within the storage capacity of the machine. The

[5] For the reports upon this code, see: R. T. Gregory. *Eigenvalues and Eigenvectors of a Symmetric Matrix.* University of Illinois, University Research Board Electronic Digital Computer Report No. 42. See also: J. O. Neuhaus, *Conversion of Latent Vector Elements to Factor Loadings.* (Manuscript on file in the University of Illinois Library).

only tasks now are to prepare the teletype tapes containing these orders and correlations and to print out and check the results.

The orders may be used with any symmetric matrix. There is no restriction to product moment correlations; the factor loadings may be obtained for any measures of correlation; e.g., tetrachoric correlations, phi coefficients, or indeed for any measures of association. If (a) the measurement matrix is multiplied by its transpose during the computation of the indices, as happens in getting covariances, product moment correlations, and phi coefficients, and (b) the diagonal entries are not reduced in any way, then the matrix may be shown to be positive definite (or positive semidefinite, if its rank is less than its order).[6] Since the matrix is also symmetrical, it is said to be Gramian.[7] If the matrix is positive definite, all latent roots are positive. If the matrix is positive semidefinite, there will be $n - m$ zero latent roots, where n = the order of the matrix and m = the rank.

Analyses can be carried out equally well with communalities inserted in the diagonal in place of unities. (Variances might equally well be reduced in the factor analysis of a variance-covariance matrix with the purpose of achieving minimal rank for the matrix.) However, if any communalities are underestimated, then the matrix will no longer be Gramian. Some of the latent roots will accordingly be negative and the associated factor loadings will be imaginary numbers. In these circumstances the Illiac supplies the correct latent root. The machine proceeds to calculate the square root of the absolute value of the latent root, so that the factor loadings are punched as real numbers. It is then necessary to supply only the symbol i at the appropriate places on the printed copy. However, all the main components will have positive roots, and any factor with a negative root may be disregarded in examining results.

If the investigator wishes to insert communalities instead of unities in the diagonal, his best procedure is to analyze initially with unities. If he then determines the number of factors he wishes to retain, he can estimate communalities (the new teletype tape

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[6] This means that all the principal minors of the matrix are greater than or equal to zero.

[7] L. R. Ford, Jr. *A Proof That the Matrices of Certain Indices of Association Are Gramian.* (Manuscript on file in the University of Illinois Library, 1953).

is readily prepared by copying the original, changing only the diagonal entries), re-analyze, and if needs be repeat the procedure on several occasions. If the factor analysis is made on product moment correlations with unities in the diagonal, then Bartlett's test (*2*, *3*) may be used to determine the number of significant components.

THE COMPUTATIONAL PROCEDURE

Two teletype tapes are read into the machine:

1) *The order tape.*—These are the general orders for the calculation of a principal axes factor analysis, applicable to any order of matrix within the storage capacity of the Illiac. These orders provide for the generation of the identity matrix of order n by the electronic computer for storage in the 'memory'. The tape is held on file, and may be used in a series of analyses.

2) *The problem and parameter tape.*—This tape consists of two parts, the problem data and the parameters. The problem section gives the correlations to be analyzed. Since the correlation matrix is symmetrical, only the principal diagonal and the lower left-hand portion of the matrix are punched on tape. The parameter section indicates to the machine (a) the order of matrix (b) the number of decimal digits desired in the results.

In preparing the problem tape, the correlations are punched by rows on a teletype key-punch. Each correlation is preceded by the sign (indicated by the sexadecimal digits corresponding to decimal '10' and '11', respectively) and by two scaling zeros (since no number greater than ± 1.00 can be stored by the machine). The punched tape may be checked in either of two ways: (a) repunching the tape, and comparing the two versions on a teletype comparing unit; (b) printing the punched tape, and reading the printed version to some second person. In the event of any mistake, this is marked on the teletype tape. The tape is then fed through a copying unit which is stopped when the error is reached, enabling any insertion, deletion, or replacement to be made.

The electronic computer time for any task falls into three sections:

1) *Input.*—The teletype tape is read by the photo-electric reader. The principal axes tape for a matrix of order 23 is read in about twenty seconds.

2) *Calculation.*—With a matrix of order 23, more than two

thousand successive sine-cosine transformations will be made in diagonalizing the matrix. These computations are carried out in about seven minutes.

3) *Output.*—Results are punched on tape. The latent root for each factor is punched first, followed by the n factor loadings. After a space in the tape, the next factor is punched. About four minutes is required for this punching.

A printed copy of results is obtained by feeding punched results through the teletype unit at any convenient time. This prints three hundred sixty characters per minute (each sign and decimal digit is a separate character). Between fifteen to twenty minutes is needed for this, but the time may be reduced by ordering the computer to punch fewer than eleven decimals for each loading. Further copies may be printed if needed.

Machine errors are rare on an electronic computer. So far as our experience goes, they are much less frequent than in the use of punched-card equipment. A machine may run for a good many hours without making any mistakes; in that time an almost incalculable number of individual operations and separate factor analyses will be carried out. In the event of error, an entire analysis can probably be repeated in less time than would be needed for finding and correcting one single punched-card mistake.

Although errors are few, routine checking of results is, of course, essential. Checking may be carried out in either of two ways:

1) A desk calculator may be used to check that the norm and the trace of the correlation matrix have remained invariant under the process of diagonalization.

2) The electronic computer may be used to check that the correlations may be restored by the multiplication of the principal axes factor loadings. The tapes with correlations and factor loadings are fed into the machine, which is ordered to indicate whether the check agrees within specified limits of tolerance. A program for the Illiac to make this check is to be prepared.

The principal difficulty in the use of an electronic computer is in the avoidance of human error. Any human error probably requires the repetition of an entire analysis, whereas any error of the same sort on punched-card equipment or desk calculator may as a rule be rapidly amended. A further difficulty is that the handling of teletype tapes presents greater problems than the handling of IBM cards when there are large sets of data to be

analyzed. A strong case can be made for the punching of the test measurements on to IBM cards rather than teletype tape, with the use of the IBM Type 63 machine for transfer of data from cards to tape. Errors are more easily corrected, and operators seem to attain greater speed on the IBM Key Punch. A case can sometimes be made for the transfer of final results back to cards by means of the IBM Type 43 machines, because of the superiority of IBM printing equipment over the teletype counterpart.

The electronic computer work makes possible the use of 'integrated programs'. Rather than calculate product-moment correlations in one machine operation and factor loadings in another, it is better for both to be calculated in a single machine run, once the two sets of orders have been integrated into one program.

SUMMARY

In view of the increasing use of electronic computers in psychological research and the resulting practicality of principal axes solutions in factor analysis, the procedure is given for the execution of a principal axes analysis on a computer. After discussion of the reasons for preferring a principal axes to a centroid solution in the initial factoring of the correlation matrix, some of the main features of the Illiac (the University of Illinois electronic computer) are described. There follows an account of the sine-cosine method which has been adopted for calculating the factor loadings, and of the day-to-day computational procedure for factorizing a correlation matrix once the appropriate set of machine orders has been prepared.

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STUDENT, SUPERVISOR, AND SELF-RATINGS OF INSTRUCTIONAL PROFICIENCY[1]

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In the evaluation of teaching proficiency there are at least two classical methods of evaluation: student ratings and supervisor ratings. The present study is concerned with the relations between these evaluative procedures and a third evaluative source—the teacher's self-evaluation of his own proficiency.

Many arguments have been put forth in favor of and against student ratings and supervisor (or peer) ratings: "the student is the consumer and hence must be the judge;" "the student is incapable of evaluating what he is learning at the time;" "the supervisor is the only one capable of evaluating, from a broad base of experience and understanding, what is to be taught;" "the supervisor does not have the opportunity to observe or his observations are distorted;" etc. These arguments have been too frequent to review here and too frequently merely argumentative. We would like to comment on the self-rating as a source of evaluation because of its more infrequent use. Basically we feel that personal learning and improvement stems from an understanding of one's own adequacies and inadequacies. We feel that a self-evaluation procedure serves to focus the individual's attention on his inadequacies and as a result he will be motivated to attempt to correct them. Admissibly this technique cannot serve as an administrative device since the man will distort these ratings for secondary purposes. However, in a non-threatening situation and in conjunction with other evaluative procedures, we feel that

[1] The present research was performed as a part of ONR Contract 816(02). The opinions or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the view or endorsement of the Navy Department.

self-ratings are a valuable adjunct to improving and evaluating teaching proficiency.

PROCEDURE

A rating scale covering seven characteristics of importance to the teaching situation was administered to fifty-one instructors. The characteristics rated were interest of the instructor in his subject, his sympathetic attitude toward students, presentation of subject matter, sense of proportion and humor, self-reliance and confidence, personal peculiarities, and personal appearance. Each of these characteristics was rated on a zero- to ten-point scale.[2]

The procedure for administering the ratings follows. The problem was explained at length to small groups of instructors, and it was emphasized that none of the results of the ratings for any individual would be disclosed. The instructors were then asked to rate themselves. After additional instruction about avoiding biasing the students, the proper number of questionnaires were given each instructor. Since the students were not required to sign their names to their rating scale, the instructor was also given an envelope which was to be sealed after being filled with the completed student ratings. The instructor's name was then put on the envelope, and it was turned into the proper phase office. In all cases the students had at least eight hours of instruction before rating their teachers. The subject matter of the course was mathematics, physics, layout and hand tools.

A meeting of all the supervisors of the instructors used in the study was next called. The nature of the problem was again explained at great length and any questions answered. The supervisors were then asked to rate their instructors on the same form. In addition they were asked to rate the instructors on an Air Force forced-choice rating form, the Instructors Description Form C which was developed by Highland and Berkshire (*1*).

Biographical information about instructors was collected from various sources. These data included the GCT score of each instructor, the amount of his formal education, the number of years he had taught, and his enthusiasm for teaching as indicated by him on a seven-point scale. A number of product-moment

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[2] This study was performed in the Naval Air Technical Training School at Jacksonville, Fla.

TABLE 1

Coefficients of correlation between:	
Instructor self-rating and student rating	.62
Instructor self-rating and supervisor rating	.16
Student rating and supervisor rating	.13
Instructor GCT score and instructor self-rating	−.25
Instructor GCT score and student rating	.21
Instructor GCT score and supervisor rating	.08
Instructor formal education and his own self-rating	−.23
Instructor formal education and student rating	.18
Instructor formal education and supervisor rating	.08
Instructor's teaching experience and his own self-rating	.05
Instructor's teaching experience and student rating	−.21
Instructor's teaching experience and supervisor rating	−.13
Instructor's enthusiasm for teaching and his own self-rating	.25
Instructor's enthusiasm for teaching and student rating	.39
Instructor's enthusiasm for teaching and supervisor rating	.00
Supervisor rating on Air Force form and on our form	.37
Supervisor rating on Air Force form and instructor self-rating	.20
Supervisor rating on Air Force form and student rating	.09
Student ratings in stanine form and difference scores between self-ratings in stanine form and student ratings in stanine form	−.13

NOTE: With a sample population of fifty-one the five and the one per cent levels of significance are 0.27 and 0.35, respectively.

correlations were computed between these data and those derived from the two rating scales. These coefficients are listed in Table 1.

DISCUSSION

Admittedly, the present study was not made in the typical educational setting. The teachers were not, for the most part, professional teachers. The supervisors were not principals or even trained professional supervisors. However, we feel our study contains certain generalities which should be considered by professional educators. After all, this was a classroom situation in which somewhat classical subject matter was being presented to typical students. Further, the supervisors were responsible for

evaluation of instruction and had previously, formally and relatively continuously been rendering such judgments.

Our main findings seem to be rather clear-cut. There is a rather high relationship between the way the student views a teacher as a teacher and the way the teacher views himself. When the limits of reliability of group-ratings and self-ratings are taken into account, this relationship is strikingly high (*2*). In other words, the teacher does have an idea of himself which is quite similar to the 'consumer's' idea when he is called upon to make such an evaluation. We feel that this insight can be used as a prime source of instructional improvement.

When we turn to supervisor ratings we find a different picture. There is little relationship between the student's view of the teacher or the teacher's view of himself and the supervisor's ratings. In fact, it is difficult to tell what is the basis of the supervisor's ratings since these were not significantly correlated with the intelligence of the instructor (AGCT), his experience in teaching, his level of schooling, or his enthusiasm for teaching. We can only conclude that the supervisor was rating on some factor or factors other than those which were valid estimates of the teaching ability of the individual or were random invalid intuitions.

Certain interesting points can be noted about the student ratings and the instructor ratings. Only one further correlation obtained was statistically significant. This was the positive correlation of .39 between the instructor's enthusiasm for teaching and the student's ratings of his teaching ability. This would clearly support the hoary but apparently sound generalization that one of the prime attributes of a good teacher is his desire to teach. We may further note that, although not statistically significant, the next two highest correlations indicated the more intelligent and the more educated instructors seem to be more self-critical (correlations of $-.25$ and $-.23$ between the teacher's self ratings and the AGCT and level of schooling, respectively).

In the particular situation it would seem possible to state that the AGCT, the level of schooling or teaching experience (within the limits of the selected population) were not significant variables in the teaching situation.

The last correlation report in Table 1 was our greatest disappointment. We hypothesized that the greater the difference between the student rating and the self-rating, the lower the

student rating would be. This was based on the assumption that widely disparate (assigned or judged) rôles between the student and the instructor would result in 'psychological friction'. As indicated by the −.13 correlation between these variables our hypothesis was not confirmed.

SUMMARY

Fifty-one instructors in a military setting were rated by their students and by their supervisors on a 'teaching proficiency' rating scale. In addition, the instructors rated themselves on the same scale. It was found that the student ratings and the self-ratings of the instructors were highly correlated. However, the supervisor's ratings were uncorrelated with any of the additional measures obtained (the instructor's AGCT, his level of schooling, his teaching experience, or his desire to teach). There was a tendency for the more intelligent instructors and those with more schooling to be more self-critical. The instructors who expressed a greater desire to teach were rated as superior teachers by their students. The discrepancy between student ratings and the instructor's ratings did not seem to be related to the judged proficiency of the teacher.

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RETROACTIVE INHIBITION IN MEANINGFUL MATERIAL[1]

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The experimental work in the area of learning has been frequently criticized from the point of view that there is little similarity between the materials used in such experiments and that found in the learning situation of the typical classroom.

This criticism is pertinent in the area of forgetting. Although most psychologists are in accord with the experimental evidence which indicates that retroactive inhibition makes a significant contribution to forgetting, most of the evidence demonstrating its operation has been done with either the traditional nonsense syllable, or the isolated noun or adjective. Those studies which have attempted to measure the susceptibility of meaningful material to retroactive inhibition have been few.

In one of the more carefully controlled studies in the area, McGeogh and McKinney (*3*) measured the susceptibility of meaningful material to inhibition generated from the interpolated learning of other meaningful material, as well as from nonsense syllables. The meaningful material was obtained from an elementary text in psychology. The results indicated that the differences in the amount recalled after varying interpolated materials had been presented (rest, nonsense syllables, and meaningful material) were not satisfactorily reliable. The failure to clearly demonstrate operation of the phenomenon would seem to indicate the need for additional research in the area.

The present study was a similar attempt to investigate the operation of retroactive inhibition with meaningful material employing two degrees of similarity between the original and interpolated material.

EXPERIMENTAL PROCEDURE

Subjects—A total of forty-five subjects, twenty-five male and twenty female college students, obtained from an introductory

[1] This study was supported by funds obtained from The American Philosophical Society.

course in Psychology, were used in the experiment. Fourteen students comprised the control group, fifteen were used in the first experimental group, and sixteen in the second.

Procedure and Materials—The conventional paradigm used in retroactive inhibition experiments was used, and was as follows: Control group: Original learning—rest—test for retention. Exp. group: Original learning—interpolated activity—test for retention.

The experimental sessions for each group were held in the evening in one of the classrooms of The Pennsylvania State University. No information was given the subjects other than telling them that they were going to participate in a learning experiment and advising them to do their best.

The same procedure was followed for all groups in presenting the original material. The prose used for this learning situation consisted of an introductory statement and thirty sentences written specifically for the experiment. Each sentence consisted of from five to eight words. The content of the material was obtained from anthropological sources and described the characteristics and customs of a hypothetical primitive tribe of people.[2] This type of material was used to reduce the possibility of subjects having familiarity with the material.

The material was presented by means of a slide projector with each slide containing a single sentence and being presented for five seconds. Approximately three minutes were required to present the total material. After the last slide was presented, the amount learned was tested by utilizing a completion test. Students were given five minutes to write in a key word, usually an adjective or noun, which had been omitted from each of the thirty sentences. Copying was eliminated by careful proctoring and by having the subjects seated in alternate seats.

The interpolated material was then presented. For the control group, this consisted of administering the Minnesota Spatial Relations test which consumed twenty-five minutes, and the DuBois-Bunch learning test (*1*) which took twenty minutes. With this latter test, it was necessary for the subject to recognize

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[2] The following sentences are representative of the material used: "The tribe is located in *northern* Africa." "Women perform most of the *domestic* tasks." (Italicized words represent the words which were omitted in the completion test.)

and record which of four key figures appeared twice in a pattern. These two tasks are far from a rest condition, but the kind of activity required to complete them seemed to be considerably remote from the kind of activity required in the original learning. The use of such activity was, of course, to prevent the subjects from rehearsing any of the original material which had been presented.

The interpolated prose material for Experimental Group 1 consisted of material describing the characteristics and customs of a second hypothetical primitive tribe. Thirty sentences were used to describe this material, with the length of each sentence being similar to sentence length of the original material. Every effort was made, however, to keep to a minimum the similarity of content between this material and the original.

The interpolated prose material for Experimental Group 2 consisted also of thirty sentences. Twenty sentences were identical to those used with Experimental Group 1. The other ten, however, were identical to ten sentences contained in the original material, except for the presence of a single word, and it was this word which was omitted in the completion test.[3] It was felt that these ten sentences of interpolated material, because of their similarity to the original material, would produce substantial amounts of inhibition of the original material. These ten items were distributed at equal intervals throughout the list of thirty.

The time required to present the interpolated prose material and to administer the completion test was approximately nine minutes.

In order to keep the amount of time spent in interpolated activities constant for all groups, the two experimental groups were administered also the Minnesota Spatial Relations test, and the DuBois-Bunch learning test. The time required to administer the Minnesota Spatial Relations test was twenty-five minutes; the time allowed for the DuBois-Bunch learning test was eleven

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[3] The following represents this relationship: (Exp. Group 1) Original material—"The tribe is located in *northern* Africa." Interpolated material—"The tribe is organized into *numerous* divisions.

(Exp. Group 2) Interpolated material: "The tribe is located in *southern* Africa."

(Italicized words represent words which were omitted in the completion test.)

minutes. Thus, for all groups interpolated activities required forty-five minutes.

After the interpolated material had been presented, the completion test covering the original material was presented. Five minutes were allowed for its completion.

Twenty-one days later, a completion test covering the original material was again presented, and five minutes permitted for its completion.

RESULTS AND DISCUSSION

Table 1 presents the results for each of the groups for the three testing periods. The results are in terms of (1) the mean number of words correctly recalled, thus completing the sentence, and (2) per cent of recall. This latter measure was obtained by dividing the mean raw score at immediate recall into the corresponding score at each delayed recall.

Although the findings indicate that Experimental Group 2 had forgotten the largest number of words, the number of omissions is not significantly larger than those made by the other two groups.

It was possible that the inhibition generated by the ten similar

TABLE 1.—NUMBER OF COMPLETION ITEMS CORRECTLY RECALLED

Group	Kind of Interpolated Material	N	Immediate		After 45 min.			After 21 Days		
			Mean	σ	Mean	σ	Per cent recalled	Mean	σ	Per cent recalled
Control	Rest	14	23.36	3.80	23.14	3.56	99.1	18.93	3.08	81.0
Exp. Gp. 1	Dissimilar material	15	23.20	3.27	23.53	3.34	101.4	19.33	3.93	83.3
Exp. Gp. 2	Similar material	16	23.31	2.14	22.94	3.84	98.4	18.81	4.59	80.7

TABLE 2.—NUMBER OF TEN COMPLETION ITEMS CORRECTLY RECALLED

Group	Kind of Interpolated Material	N	Immediate		After 45 Min.			After 21 Days		
			Mean	σ	Mean	σ	Per cent recalled	Mean	σ	Per cent recalled
Control	Rest	14	8.64	1.23	8.57	1.40	99.2	7.21	1.47	83.4
Exp. Gp. 1	Dissimilar items	15	9.07	1.24	9.07	1.39	100.0	7.47	1.36	82.4
Exp. Gp. 2	Similar items	16	8.63	1.05	8.63	1.27	100.0	6.69	1.79	77.5

items found in the interpolated material for Experimental Group 2 was not sufficiently large to produce significant differences between the groups in the recall of the original material. Consequently, a separate analysis of these ten items was made, and is indicated in Table 2.

Here again, significant differences in omissions do not appear at either the forty-five minute or the twenty-one day interval, although this latter recall period reveals Experiment Group 2 again had the largest amount of decrement.

It is interesting to note that the present results closely parallel those of McGeogh and McKinney (*3*). Not only do we find small amounts of inhibition generated by interpolated material, but find, also, almost equal potency of the three kinds of interpolated material on the inhibition of the original material. This is particularly puzzling inasmuch as we have deliberately introduced similar interpolated material, which, according to McGeogh (*2*), and the recent theorizing of Osgood (*4*), should have produced substantial amounts of inhibition of the original material.

It is apparent from these results as well as the results of others that more investigation is needed in this area in order to substantiate the hypothesis that retroactive inhibition makes an important contribution to the forgetting of meaningful material.

SUMMARY

This experiment was an attempt to demonstrate the operation of retroactive inhibition with meaningful material. The conventional RI paradigm was employed. Three groups of subjects were presented with meaningful material, and a completion test was utilized to measure the amount learned. Interpolated material was then presented, with Experimental Group 1 receiving dissimilar meaningful material, and Experimental Group 2 receiving similar meaningful material. A control group did not receive any meaningful interpolated material. Forty-five minutes and twenty-one days later, the amount of original material recalled was measured for all groups. Results indicated no significant differences among the groups.

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NOTE ON THE VALIDITY OF THE ARMY GENERAL CLASSIFICATION TEST AS A PREDICTOR OF ACADEMIC ACHIEVEMENT

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The lack of validity data and college norms for the Army General Classification Test limits its use by college personnel workers and administrators for counseling and selection purposes. One study (*1*) has appeared in the literature in which means, standard deviations, and validity coefficients are reported for various groups of officer candidates and ASTP cadets, but nothing has been reported with respect to use of the AGCT with college students in a civilian setting.

In the fall of 1951 the AGCT was administered to all University of Missouri male freshmen registered for the basic Army and Air Force ROTC courses. These men were enrolled in one of the four colleges which are regularly open to freshmen (Agriculture, Arts & Science, Education, and Engineering). At the end of the school year AGCT scores (Army standard scores) and first-year grade point averages were correlated. It was found that, for this group, the AGCT is about as good a predictor of academic achievement as any of the other tests used in the freshman placement test battery at the University of Missouri. This battery consists of: (1) The ACE Psychological Examination, 1942 edition; (2) Coöperative English Test A: Mechanics of Expression, Form S; and (3) Coöperative English Test B2: Effectiveness of Expression, Form S.

The test used in the present study was AGCT-1c which has been calibrated to AGCT-1a; the correlation between the two forms being .90 (*2*). AGCT-1a is the form which has been released for civilian use (*3*), and is now referred to as the first civilian edition, forms AH(hand scored) and AM(machine scored).

Validity data and college norms for AGCT-1c are presented in Tables 1 and 2, respectively.

TABLE 1.—VALIDITY COEFFICIENTS OF THE AGCT AS A PREDICTOR OF ACADEMIC ACHIEVEMENT

Group	N	Mean	SD	r
Agriculture	277	118.1	11.0	.47
Arts & Science	389	121.6	10.1	.43
Education	38	118.8	11.4	.39
Engineering	107	125.9	10.5	.36
Total	811	120.8	10.8	.41

TABLE 2.—PERCENTILE EQUIVALENTS FOR ARMY STANDARD SCORES ON THE ARMY GENERAL CLASSIFICATION TEST*

AGCT Score	Percentile	AGCT Score	Percentile
151–154	100	121	55
145–150	99	120	51
143–144	98	119	46
141–142	97	118	42
140	96	117	38
139	95	116	35
138	94	115	32
137	93	114	27
136	92	113	23
135	91	112	20
134	90	111	17
133	88	110	14
132	86	109	12
131	84	108	10
130	82	107	8
129	80	106	7
128	77	104–105	6
127	73	102–103	5
126	69	100–101	4
125	66	99	3
124	63	95–98	2
123	60	88–94	1
122	58	76–87	0

* Based on 992 University of Missouri male freshmen (1951–52).

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BOOK REVIEWS

GLENN MYERS BLAIR, R. STEWART JONES AND RAY H. SIMPSON, *Educational Psychology*. New York: The Macmillan Company, 1954, pp. 601. $4.75.

L. J. CRONBACH, *Educational Psychology*. New York: Harcourt, Brace & Co., 1954, pp. 628. $5.50.

W. D. COMMINS AND BARRY FAGIN, *Principles of Educational Psychology*. New York: The Ronald Press Co., Second Edition, 1954, pp. 795. $5.75.

H. H. REMMERS, EINAR R. RYDEN AND CLELLEN L. MORGAN, *Introduction to Educational Psychology*. New York: Harper and Brothers, 1954, pp. 435. $4.00.

HENRY P. SMITH, *Psychology and Teaching*. New York: Prentice-Hall, Inc., 1954, pp. 466. $4.95.

HERBERT SORENSON, *Psychology and Education*. 3rd Edition. New York: McGraw-Hill Book Company, Inc. 1954, pp. 577. $5.50.

It is a matter of no small interest that six textbooks in Educational Psychology should have appeared in the Spring of 1954. Two of these are editions of books that have been on the market for some years, but four are new. There is no way of knowing why there should be such an avalanche of texts in this field appearing within a few months of each other, but undoubtedly part of the explanation can be found in the fact that these books are good sellers and money-makers. A recent report on "Psychologists in Teacher-training Institutions"[1] shows that educational psychology texts are a close second to general texts in psychology used in these institutions. Undoubtedly the authors of these new texts have hoped to catch some of this market.

In order to determine the trends which these new books represent, a tabulation was made of the per cent of page space devoted to various topics to be compared with a similar tabulation of the page space of six books having wide use and popularity at the present time. These tabulations are reported in Tables I and II.

These six new books in Educational Psychology show marked differences from similar text available two and three decades ago.

[1] P. M. Symonds, S. Z. Klausner, J. E. Horrocks and V. H. Noll. "Psychologists in teacher-training institutions," *The American Psychologist*, 7: 24–30, 1952.

TABLE I.—PERCENTAGE OF PAGES DEVOTED TO TOPICS IN EDUCATIONAL PSYCHOLOGY, NEW 1954 BOOKS

Topic	Textbooks						
	Blair	Commins	Cronbach	Remmers	Smith	Sorenson	Average
Learning	18.4	28.9	25.1	10.2	21.1	30.5	22.3
Development (physical, emotional, mental)	12.2	7.1	3.0	6.8	14.4	15.8	9.9
Social development	7.7	14.9	5.0	15.5	7.2	5.3	9.3
Individual differences, intelligence	6.5	20.8	5.4	6.3	13.6	8.6	10.2
Motivation	7.5	4.5	10.0	0.8	5.3	7.9	6.0
Adjustment, personality, mental hygiene	14.5	9.1	12.8	30.4	15.9	13.2	16.0
Measurement and evaluation	19.5	5.4	14.3	30.2	6.2	12.1	14.6
Attitudes and interests	3.6		8.2		7.9		3.3
Psychology of the teacher	10.1		8.9		8.4	6.4	5.6
General orientation to education and psychology		9.3	7.3				2.8

There is practically no reference to the nervous system; indeed, most textbook writers have swung too far in the direction of proclaiming their ignorance of the exact connection between mental activity and nervous activity. At least, these reviewers hold that students should know that most psychologists believe that there is such a connection, even though the details have not yet been worked out. There is also little emphasis on the history of psychology, and most of these new textbooks give little mention to some of the early names such as G. Stanley Hall, William James, E. L. Thorndike, William MacDougall, or even more contemporary names, such as Clark Hull, C. E. Skinner and Edward Tolman. There is a tendency to minimize the several schools of psychology, and these texts pay little attention to theoretical issues which have interested experimentalists over the last decade. Most of these texts give a straight-forward explanation and description of learning without introducing technical terms or going into matters of theory and controversy.

From the tabulation we learn that the current crop of texts in Educational Psychology gives less space to topics of learning and development than those that preceded them. On the other hand,

TABLE II.—PERCENTAGE OF PAGES DEVOTED TO MAIN TOPICS IN EDUCATIONAL PSYCHOLOGY, BOOKS IN CURRENT USE

Topic	Textbooks*						
	Cole	Gates	Pressey	Skinner	Sorenson	Trow	Average
Learning	31.7	15.6	32.6	29.8	30.3	41.7	30.2
Development (physical, emotional, mental)	16.4	21.2	19.2	15.0	16.3	12.2	16.7
Social development	5.3	6.8	11.0	4.0	4.0	15.4	7.7
Individual differences, intelligence	7.9	5.1	8.2	12.3	16.7	6.3	9.4
Motivation	6.2	1.5		3.0	9.4	6.3	4.4
Adjustment, personality, mental hygiene	13.8	29.3	7.4	21.4	10.6	5.6	14.7
Measurement and evaluation	8.8	13.2	5.6	7.3	9.5	5.6	8.3
Attitudes and interests			16.1	3.6			3.3
Psychology of the teacher	4.0	5.1			3.2	4.3	2.8
General orientation to education and psychology	5.7	1.9		3.4		2.2	2.2

* L. E. Cole and W. F. Bruce, *Educational Psychology*. Yonkers-on-Hudson, World Book Co., 1950. A. I. Gates, A. T. Jersild, T. R. McConnell and R. C. Challman, *Educational Psychology*, 3rd Edition, New York: The Macmillan Co., 1923, 1930, 1942, 1948. S. L. Pressey and F. P. Robinson, *Psychology and the New Education*. New York: Harper and Bros., 1933, 1944. C. E. Skinner, Editor, *Educational Psychology*, 3rd edition. New York: Prentice-Hall, Inc., 1936, 1945, 1951. Herbert Sorenson, *Psychology in Education*, 2nd edition. New York: McGraw-Hill Book Co. Inc., 1940, 1948. W. C. Trow, *Educational Psychology*, 2nd edition. Boston: Houghton Mifflin Co., 1931, 1950.

space is distributed over a somewhat wider range of topics, which means that slightly more emphasis is given to problems of measurement and evaluation, motivation, adjustment, personality, mental hygiene, social psychology, and the psychology of the teacher. One very important trend that these reviewers have noted is the attempt to breach the gap between theory and educational practice. This has perhaps been one of the most cogent criticisms of educational psychology texts in the past—that they have reported well the results of psychological experiments, but that they had not translated these results into suggestions that would be helpful to the teacher. In these texts there is less reporting of the results of

the experimental studies and more interpretations of the results of these studies in terms of educational practice and procedure.

The book by Blair, Jones and Simpson represents a rare piece of teamwork. We are told in the Preface that Blair has been responsible for the introductory chapter, Part II dealing with growth and development and three of the four chapters in Part IV, dealing with adjustment and guidance. Jones has taken as his responsibility Part III, dealing with learning as well as Chapter 16 on studying the individual child. Simpson has been responsible for Part V on measurement and evaluation and Part VI on the psychology of the teacher. This distribution of responsibility in the book is somewhat puzzling to these reviewers because each author seems to have gone out of character somewhat, if one may judge by his previous writings and interests. For instance, Blair is best known through his earlier book on *Diagnostic and Remedial Teaching in Secondary Schools*,[2] so that one would have expected him to have taken responsibility for chapters on learning and applications of learning to classroom situations. Likewise Simpson's earlier book, *Improving Teaching-Learning Processes*,[3] would lead one to expect him also to have contributed chapters on the application of the principles of learning to teaching procedures instead of chapters on measurement and evaluation for which he is responsible in the present book. On the other hand, Jones' previous writings, including his doctoral dissertation dealing with *Integration of Instructional with Self-scoring Measuring Procedures*,[4] would have led one to expect him to have written chapters on measurement and evaluation instead of the chapters on learning.

The merit of this book resides in the interpretation of experimental results and theory into principles of teaching and applications to classroom procedures. These authors not only present the results of studies that have been reported in the literature, but tie these findings to applications to the school situation.

Cronbach's book was first tried out in mimeographed form in his

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[2] G. M. Blair. *Diagnostic and Remedial Teaching in Secondary Schools*. New York: The Macmillan Co., 1946.

[3] R. H. Simpson. *Improving Teaching-Learning* Processes. New York: Longmans, Green & Co., 1953.

[4] R. S. Jones. *Integration of Instructional with Self-scoring Measuring Procedures*. Unpublished Ph. D. dissertation, Ohio State University, Columbus, Ohio, 1950.

classes over a period of years and whatever merits the book possesses may be attributed in part to the suggestions and criticisms made by his students. Cronbach has done a superb job in bridging the gap between theory and practice, and has made notable steps forward in interpreting the results of experimental studies in terms of their classroom applications. These reviewers find the chapters on "Purposes and Aspirations," "The Teacher as a Classroom Leader," and "Personality Structure and Character Development" excellent: these chapters representing a somewhat new emphasis in texts of this kind. Since Cronbach is recognized as a leader in measurement, statistics and research, one might expect an overemphasis of these topics in the book. On the contrary, measurement has been fitted in without undue emphasis, problems of the measurement of ability and aptitude being taken up under the general heading of 'readiness', and problems of the measurement of achievement being taken up under the heading of 'evaluation'. The book itself is attractively published, and there is evidence that both author and publisher took a great deal of pains in the manufacture of the book. There is a copious use of pictures, but the reviewers feel that, contrary to the use of pictures in some current textbooks, Cronbach has made his pictures really instructive and they have added to the text itself. There are summaries, questions and reading lists at the end of the chapters which make the book of greater use to both the instructor and the student.

The book by Commins and Fagin represents a thorough revision and rewriting of their earlier book of seventeen years ago. This text is one of the most scholarly of the group. There are references to historical developments in psychology and attention is paid to the theoretical differences between the several schools of psychology. Careful definitions of terms are given.

The emphasis in this text is on gestalt and field theory. One notes that the heroes of these two writers are Tolman, Wheeler and Perkins, Humphrey, Hartmann, Lewin, and other field theorists. These reviewers found the chapters on thinking processes and problem-solving particularly valuable. It is of note that those who approach these topics from the point of view of connectionistic psychology have less to contribute than those who approach them from the point of view of field theory.

The book by Remmers, Ryden and Morgan also represents the team approach. However, in this book the integration of the sev-

eral sections of the book is not so clearly apparent. We are not told in the Preface the responsibility of each of the three authors, but there is evidence that the senior author has been influential throughout, if indeed he has not actually written chapters in most of the sections of the book. Morgan apparently has contributed from his experiences with the Veterans Administration to the first six chapters in the book dealing with adjustment. A seventh chapter, dealing with a sociological perspective on education, has been prepared by Schneider. The two chapters on learning, we are told, were written with the assistance of Floria Fischer.

This book is not designed with the needs of teachers exclusively in mind, as there are chapters dealing with the extent to which home conditions and the community can contribute to adjustment.

The last part of the book is heavily weighted with an emphasis on individual differences, problems of testing, and the statistical treatment of test results. These reviewers are a little puzzled by the introduction of a chapter on "Interpreting Test Scores" in an elementary text in educational psychology, and wonder to what extent the authors expect the student in a beginning psychology class to master the elements of statistical methods. The inclusion of an appendix in the book, dealing with measures of relationship, seems even less appropriate. Indeed, the book is very heavily weighted with statistical concepts. For instance, on page 1 we are told that "psychologically a normal individual is at best a statistical fiction," and in the chapter on "How and Why We Learn," in the section dealing with reasoning, we find the following given as an illustration: "Let us now look at a student's effort to enlarge upon or formulate a concept. Let us take as an example the concept of an average as exemplified by the formula: average = $\Sigma m/N$ (sum of all the measures divided by the number of measures)." (p. 269).

Certain portions of this book lead the reviewers to the impression that it was written several years ago. For instance, in the chapter on "Achievement Testing" with one sole exception the last reference is dated 1941. Perhaps the authors feel that there has been little added to the literature on achievement testing in the last thirteen years. There are sections in this book that make one believe that the authors have not kept up with contemporary developments in psychological thinking. For instance, on pages 280 and 281 it is clearly implied that reward and punishment operate in opposite directions, whereas it was in 1929 that Thorn-

dike clearly stated that punishment did not result in the diminution of strength of a connection in the same way that a reward helps to strengthen a connection.

These authors have provided an elaborate study manual to be used in connection with the text.

The book by Smith is described on the jacket as a new approach to educational psychology. Unfortunately with so many competitors this book cannot claim quite so much originality, but at the same time it has several features which make it desirable as an elementary text. Smith has avoided giving attention to the controversies that command the attention of advanced students. He has chosen to omit any historical orientation to the topics in educational psychology and he has written with a minimum of technical vocabulary. This is perhaps one of the most elementary of the texts being reviewed and this probably was the author's intention. There is a good balance in the distribution of topics in the book between development, learning, and motivation. An introductory chapter deals with the teacher as a professional worker, reporting some of the characteristics of the good teacher and some of the problems most frequently met by teachers, as an introduction to the main topics in the book itself. The topic of evaluation is limited to one chapter. This author has been as successful as any in interpreting the scientific principles which have been developed over the years in terms of classroom practice.

The book by Sorenson, which is the third revision of this widely used text, represents the author's and publisher's continued efforts to keep the text abreast of the times. This book has been collated with the McGraw-Hill Text-Films on Educational Psychology. The arrangement of topics is somewhat unusual. The book begins with a chapter on "Measuring the Learning and Achievements of Pupils." We are told that this chapter is placed early so that the instructor can give his attention at the beginning of the course to the basis on which he will assign marks to students in his course, and so that the students will know how they are to be graded. Chapter III deals with the problem of study, and this, too, has been placed early because the author believes that students need early guidance and instruction in the art of study. In general, the problem of growth is taken up in the book before learning. Physical growth is treated before emotional growth, and the problems of

intelligence and its measurement and its relation to heredity precede the discussion of learning. Each chapter is introduced by a section entitled "What To Look For" that raises questions which the student is to keep in mind, the answers to which are to be found in the text. Following this section there is an introductory paragraph in each chapter giving an anecdote or incident which serves as a kind of text for the subsequent discussion. At the end of each chapter there is a summary and review and finally a brief "Test Your Thinking." At the end of the book there is a glossary and a very ample bibliography.

In comparing this third revision with the revision which preceded it, we find less attention given to individual differences in intelligence and more attention to problems of adjustment, personality and mental hygiene. Sorenson also gives greater space to measurement and evaluation in this last revision and also to the psychology of the teacher. Supplementary materials have been prepared including a teachers' manual which contains materials which can be used for testing and a workbook to be put into the hands of students to help them in outlining and applying materials presented in the text.

It will perhaps be superfluous for these reviewers to predict trends which they foresee in the next batch of new and revised educational psychologies, but here are some of the trends as we see them. In the first place, there must be an inclusion in our texts on educational psychology of some of the recent developments in social psychology, particularly those having to do with group dynamics, the psychology of the group process both in small groups and large groups. Some of the current findings of problems of leaderships, of group morale and of group thinking must find their way into our educational psychology texts. Greater attention will be paid in the future to problems of teacher-pupil relationships, and some of the findings coming out of psychotherapy dealing with problems of transference and resistance have their direct applications to the classroom situation. Indeed, there should be further applications of principles of motivation and dynamic psychology to the problems of teaching and learning. Finally, there are new developments in our understanding of the rôle and function of the teacher as a person and of the part that dynamic factors in the teacher's personality play in the teaching situation. These new

emphases and topics must be not merely superimposed upon but integrated with the principles that have already been developed concerning development, learning, individual differences and the problems of evaluation.

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